

Finite element model of a light airplane with embedded control mechanisms for parametric analysis of free vibrations and flutter

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Abstract. The work presents an aeroelastic model and flutter analysis for a Very Light Airplane (VLA) using MSC Patran/Nastran. The airframe structure was modeled with shell and beam elements to replicate thin-walled components. Validation of mass model parameters included both structural and non-structural masses, accounting for onboard equipment, installations and propulsion system. Global stiffness was verified through static analysis carried out for extreme aerodynamic loads. The natural vibration modes and frequencies were determined, incorporating control surface oscillations. The numerical flutter analysis utilized an aeroelastic model, combining the structural FEM model with an aerodynamic panel-body model via the Doublet Lattice Method (DLM), leading to the identification of critical speeds for the flexural-aileron flutter of wings and the tail oscillations with contribution of control surfaces flapping. To consider stiffnesses effect of control mechanisms, their partial kinematic models were added. The additional stiffnesses and masses from pilot's hands or legs impacting natural frequencies and critical flutter velocities were considered. Parametric analyses were performed for various grip stiffnesses and artificially-added masses put on the control stick and pedals. The graphs illustrate the relationship between these variables and critical flutter velocities, highlighting the significant influence of pilot's effect on vibration characteristics.